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Helminthology in its Application to Agriculture and Horticulture

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Helminthology in its Application to Agriculture and Horticulture.*

By Marjorie J. Triffitt, D.Sc.

Introduction.

Helminths infecting plants are termed "eelworms" and that term covers a vast and miscellaneous assemblage of nematodes comprising hundreds of genera and thousands of species. Although they are usually very small—the adults in some cases being scarcely visible to the naked eye, they display as great a diversity in form as almost any other zoological group, and in their habitat and biology are correspondingly varied. Although the great majority of terrestrial forms are harmless, free-living or saprophytic organisms, a few species have become adapted as plant parasites, and within recent years have been shown to be the causal agents of several plant diseases of the utmost economic importance. The general lack of knowledge regarding the plant-parasitic nematodes has been responsible for their almost world-wide distribution, which has been furthered by the remarkable adaptability and powers of resistance against adversed conditions shown by the eelworms themselves. As examples of this *Anguillulina dipsaci* and *Heterodera schachtii* may be quoted :—the larvæ of the former will revive when re-moistened after remaining in a desiccated condition for 7 years, while the latter can lie dormant in soil for a period of over 10 years. The intensive methods of cultivation practised on the most fertile land provide ideal conditions for nematode parasites, and hence, it is in the richer areas that nematode diseases cause the greatest damage.

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The parasitic nematodes which are responsible for most plant diseases of economic importance belong to three genera, viz. *Pathoaphelenchus*, formerly known as *Aphelenchus*, *Anguillulina*, formerly known as *Tylenchus*, and *Heterodera*. These have certain morphological characters in common, chief among them, the possession of a spear-like organ in the buccal cavity which possibly serves to effect an entry into the host tissues. The degree of adaptation to parasitism differs in the three genera, *Pathoaphelenchus* containing the least and *Heterodera* the most highly specialised forms.

Pathoaphelenchus.

The *Pathoaphelenchus* species are ectoparasites during part of their life-cycle, and always attack the aereal parts of the plant. Of these, *P. ritzema-bosi* and *P. olesistus* are pests of horticultural importance. The former causes a serious disease of chrysanthemums and other plants, especially under glasshouse conditions, and the latter causes leaf-blotch in ferns and orchids. In both cases the worms crawl up the stems of the plants and on to the leaves which they enter by the stomata. They break down the mesophyll of the leaf, causing discoloured spreading patches. Rapid reproduction takes place and the young larvæ emerge and make their way to new leaves, ultimately causing the death of the plant.

Several other species of *Pathoaphelenchus* are found associated with disease conditions, but have not been definitely proved to be the cause of the symptoms. Of these, *P. fragariæ* which is associated with the disease of " red plant " in strawberries, and *P. cocophilus* which occurs in the tissues of coconut palms attacked by the fatal " red-ring " disease, may be mentioned.

Anguillulina.

The second genus of plant infesting nematodes, *Anguillulina* vel. *Tylenchus* is of greater economic importance than *Pathoaphelenchus*. The parasitic species of this genus enjoy a distribution of from within the arctic circle, where cereals and grasses are attacked, to the equatorial zone, where diseases are produced in coffee, tobacco, sugar cane, bananas, and many other crops.

Both root and shoot structures are attacked by this genus. *A. similis.*

A. pratensis and *A. radicicola* are all parasites of root-structures. *A. similis* occurs in tropical and sub-tropical regions and causes a soft brown rot in the roots of coffee, bamboo, pineapple, sugar-cane and several other plants. *A. pratensis* causes similar damage but is more widely distributed, occurring in the United States of America and in Europe as far north as Poland and Sweden, as well as in tropical Africa, the East Indies, Hawaii and Mexico, and has a correspondingly wide host range. *A. radicicola* occurs only in northern Europe and confines its attack to members of the Natural Order Gramineæ. It is, however, a serious pest in Norway, Denmark and Sweden where it attacks rye, wheat, barley and other crops, producing galling of the roots and consequent reduction in yield.

A. angusta, which parasitises the shoot structures of rice, has been found both in India and Malaya.

A. tritici is the cause of " cockle " in wheat. At first ectoparasites, the larvæ climb to the growing point of the young seedling and are carried up by the growth of the stalk to the inflorescence where they penetrate the tissues, feed and multiply at the expense of the flowers and produce a blackish gall filled with thousands of larvæ, in place of a grain of wheat. The use of seed contaminated with these galls or cockles is responsible for the distribution of the parasite.

One of the most important species, *Anguillulina dipsaci*, also a stem infesting form, is known to attack more than 200 species of plants, many being valuable agricultural crops. It is responsible for tulip-root in oats, clover-sickness, a potato-rot, a mangold-rot, and a disease of narcissus bulbs in this country alone. Most of the life-cycle is passed within the tissues of the host and a twisting and general deformity in addition to the rotting of affected parts characterises the infection. Owing to the large number of susceptible plants, this nematode, having once been introduced into clear land may overwinter in weeds and is therefore difficult to control.

Heterodera.

The third genus, *Heterodera*, contains only three species all of which are parasites of economic importance. The two most important of these, *H. marioni* and *H. schachtii*, were originally distributed in tropical and temperate zones respectively, but *H. marioni* has been known as a pest

in glasshouses in this country for some years and has recently been found to have established itself as a field parasite in Wiltshire. *H. schachtii* on the other hand has been introduced into the tropics where it is proving an even deadlier pest than *H. marioni*.

The life cycles of the two differ slightly. *H. marioni* is a gall-former. The larvæ penetrate the roots of the host, causing a gall in which they develop and reproduce. The mature female is a white pear-shaped body about the size of a pin's head. Each female lays several hundred eggs which quickly hatch. Some of the larvæ continue their development within the gall, others escape to infect fresh roots. The young larvæ form the over-wintering stage, and can remain viable for many months in moist soil.

H. schachtii is not a gall-former and the eggs are retained within the spherical or pear-shaped body of the female. This protrudes from the root, and, at first white, later becomes a tough brown envelope forming a protective covering for several hundred eggs. This stage, the " brown cyst," drops from the root into the soil where it remains dormant until conditions are suitable for the hatching and liberation of the larvæ.

Both species cause the death of the attacked roots and consequently the stunting or death of the plants. *H. marioni* occurs practically throughout the whole of the tropical, semi-tropical and warmer temperate zones, and has been recorded from about eight hundred species of host plants, among which are numbered almost every crop of agricultural and horticultural importance including many trees of value both for fruit and timber. *H. schachtii* is widely distributed throughout Europe where it attacks chiefly potatoes, oats, peas and beet ; it is a serious pest of sugar-beet in the United States, and of cereals in Australia, occurs on beet, cereals, and hemp in South Africa, and causes considerable damage to pineapples in the West Indies.

Biological Strains.

An interesting and very important peculiarity in the biology of plant-infesting nematodes is their power of becoming highly specialised for a single host plant and thereby losing almost entirely the power of attacking other plants. These highly specialised populations are known as biological strains, and have given rise to some confusion in nomenclature, owing to being named as separate species or sub-species. This phenomenon of

biological strain formation is most marked in the case of *H. schachtii*. In Britain alone several distinct strains exist which attack potatoes, mangolds, hops and peas respectively. Of these the potato-strain is the most widely distributed and the most important. It is the cause of a disease known as "potato sickness" which has rendered hundreds of acres of fertile land, notably in Yorkshire and Lincolnshire, quite useless for potato growing. The severity and importance of the disease may be judged from the fact that "warp" land, ordinarily valued at £50 per acre drops in value when infected with this eelworm to only £15. *H. marioni* on the other hand seldom shows any degree of specialisation, and almost any crop grown upon infected land is liable to attack.

Control.

Practical methods of controlling nematode diseases are almost unknown. Under horticultural conditions some of the *Pathoaphelenchus* species may be checked by ringing the stems of plants with tanglefoot which prevents the nematodes from climbing on to the leaves. The partial sterilisation by steam of soil used in glass-houses and for seed-beds is effective in cleaning nematode infested soil. A hot water treatment has been devised for ridding narcissus bulbs of *Anguillulina dipsaci*. The bulbs are immersed in water at 110° F. for 3 hours, and variations of this treatment can be used for other valuable horticultural stock. Cockle in wheat can be controlled by the use of clean seed, or, if this is unavailable the galls can be floated out in brine without damage to the rest of the seed. The use of contaminated seed and nursery stock is largely responsible for the spread of nematode diseases. *H. schachtii* is spread by the inclusion of minute quantities of infected soil among seed potatoes or beet seed and once it becomes established in any area it is rapidly spread by the transport of infected soil on agricultural implements, the feet of animals, flood water, etc. *H. marioni* is disseminated in the same way as well as by the transplanting of infected seedings. There is no known method adapted to use on a field scale of ridding infected soil of either of these parasites except by long rotations. *H. marioni* can be starved out by fallowing for 3 or 4 years, but owing to its polyphagous habit the ground must be kept absolutely free from all vegetation as any weeds may serve as reservoirs of infection. Where a highly specialised strain of *H. schachtii* occurs a rotation of non-susceptible crops can be

practised. This treatment must, however, be continued for many years, as many of the larvæ tend to remain unhatched in the protective brown cysts until they receive a stimulus which is created by root excretions of the customary host plant. As a 10 year rotation is insufficient to rid soil completely of this pest, research is being carried out on methods of producing the stimulation in the absence of the host plant. Plant breeding has produced varieties of barley rye and beet resistant to attack by *H. schachtii*, and various degrees of varietal immunity to *H. marioni* have been found to exist in sweet potatoes, cow-peas, velvet beans and peaches.

Further work is being done on these lines. Meanwhile a practical measure already being taken, notably in Sweden, is to restrict the import of agricultural produce from countries known to be infected with nematode diseases. This is a precautionary measure which might well be extended.

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